

GRAZING MANAGEMENT

Grazing-Tolerant Alfalfa Cultivars Perform Well under Rotational Stocking and Hay Management

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ABSTRACT

Grazing-tolerant alfalfa (*Medicago sativa* L.) cultivars are developed using continuous stocking with beef cattle (*Bos taurus*) during screening and selection. Alfalfa is mainly recommended for use in hay making and under rotational stocking rather than continuous stocking. Performance of alfalfa cultivars selected under the specificity of intensive, continuous stocking in recommended management systems is unknown. This study was conducted to test survival and performance of alfalfa populations selected with continuous stocking against their parental cultivar germplasms ('Apollo', 'Diamond', '5432', and 'Florida 77') at two Georgia locations (Eatonton and Tifton) under the following management conditions: grazing to close stubble heights (5–7 cm) with continuous stocking, grazing to close stubble heights (5–7 cm) with rotational stocking (7 d grazing and 28 d rest), and standard hay harvesting. At Eatonton, plant survival was similar (52–53%) for the rotational stocking and hay harvest treatments, with all entries in these treatments exhibiting better survival than in the continuously stocked treatment (38%). At Tifton, stand survival improved as management changed from continuous stocking (24%) to rotational stocking (46%) to hay harvest management (63%). At both test locations, grazing-tolerant entries demonstrated higher plant survival rates than parental populations when averaged across all management treatments. Dry matter yields of the grazing-tolerant entries were no different, or were higher during 1 yr at Tifton, than their parental populations. It is therefore a good strategy for producers practicing continuous stocking, rotational stocking, or hay making to use grazing-tolerant cultivars rather than cultivars not selected for grazing tolerance.

A STANDARD TEST to screen alfalfa cultivars for grazing tolerance has been included in the North American Alfalfa Improvement Conference (NAAIC) *Standard Tests to Characterize Alfalfa Cultivars* manual (Bouton and Smith, 1998). The test relies on heavy grazing with continuous stocking during screening and is not intended to be used as a grazing recommendation for producers. Reselection and intermating of surviving plants from nontolerant cultivars across a range of fall dormancy groups after this type of grazing showed increased grazing tolerance in the selected populations as measured by procedures identical to the standard test (Smith and Bouton, 1993). 'Alfagraze' was the first graz-

ing-tolerant cultivar developed with this approach (Bouton et al., 1991). Several currently marketed cultivars were developed using similar procedures (Moutray, 2000). These grazing-tolerant cultivars have increased the value and use of alfalfa as a grazing crop in recent years due to the removal of farmer concerns about using alfalfa for direct grazing (Henning, 2000).

To achieve the best production and performance, alfalfa is mainly recommended for use in hay making and under rotational stocking and not continuous stocking (Van Keuren and Matches, 1988). In reality, most producers in commercial practice probably do not use continuous stocking. However, if continuous stocking is practiced, results indicated that high forage allowance (approximately 1100 kg of dry matter per animal unit) is needed to maintain the longest stand life and least weed encroachment (Bates et al., 1996). Therefore, a logical question would be "do grazing-tolerant alfalfa cultivars as defined by the standard test perform well in recommended management systems such as hay making and rotational stocking?" The objective of this study was to test survival and productivity of alfalfa populations selected after grazing with continuous stocking against their parental cultivar germplasms at two locations in Georgia under the following management conditions: grazing to close stubble heights with continuous stocking, grazing to close stubble heights with rotational stocking, and standard mechanical hay harvesting.

MATERIALS AND METHODS

These experiments were conducted at Eatonton and Tifton, GA. The Tifton trial was established in a Tifton sandy loam soil (fine-loamy, siliceous, thermic, Plinthic Kandudult) at the University of Georgia Coastal Plain Experiment Station. The Eatonton trial was established in a Mecklenburg sandy loam soil (fine, mixed, thermic, Ultic Hapludalfs) at the University of Georgia Central Georgia Branch Station.

At both locations, the treatment design was different alfalfa entries and management conditions of continuous stocking, rotational stocking, and hay harvest. The experimental design was a split plot arranged in five randomized complete blocks, with management conditions as main plots and alfalfa entries as subplots. Main plots measured 11 by 6 m, and each subplot was 1.5 by 4.5 m.

At Tifton, entries were Florida 77, 'GA-FL77-S2', Diamond, 'GA-Diamond-S2', Alfagraze, and Apollo. At Eatonton, the entries were Alfagraze, Apollo, 'GA-Apollo-S2', 5432, and 'GA-5432-S2'. GA-FL77-S2 is a grazing-tolerant cultivar from Florida 77 that was released as 'ABT 805' (Bouton et

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Abbreviations: NAAIC, North American Alfalfa Improvement Conference.

al., 1997a). GA-Diamond-S2 is a grazing-tolerant population selected from Diamond. GA-Apollo-S2 is a grazing-tolerant population selected from Apollo. GA-5432-S2 is a grazing-tolerant population selected from 5432. Alfagraz is the grazing-tolerant check and Apollo and 5432 are the intolerant checks from the standard test (Bouton and Smith, 1998). Using two cycles of recurrent selection as described by Smith and Bouton (1993), GA-Diamond-S2, GA-Apollo-S2, and GA-5432-S2 were developed from plants surviving grazing to close stubble heights (5–7 cm) for >100 d with continuous stocking by beef cattle. Similar selection and screening methods were used to produce Alfagraz (Bouton et al., 1991) and GA-FL77-S2 (Bouton et al., 1997a).

The experiment was established in October 1996 within a 0.5-ha grazing paddock that was continuously stocked with two to four beef animals throughout the grazing season (e.g., April–November) in each of the next 2 yr (1997–1998). Each entry was sown at 22 kg ha⁻¹ seed. The balance of the paddock contained bermudagrass (*Cynodon dactylon* L.). Land preparation, liming, fertilization, and pest control for establishment and maintenance were standard for alfalfa performance plots and were similar to those described previously (Smith and Bouton, 1993; Bouton et al., 1998). Lime and fertilizer application at each location can be summarized as follows: dolomitic limestone applied at 4480 kg ha⁻¹ and P and K applied at 50 and 200 kg ha⁻¹ and disked into the soil before sowing. Phosphorus and K were reapplied (broadcast) each year in the early spring at 56 and 224 kg ha⁻¹, respectively.

Step-in electric fence was used around each main plot to control the desired management conditions: all animals excluded from the hay main plots at all times, animals allowed access to the rotational stocking area for 7 d and then excluded for 28 d, and animals allowed access to the continuous stocking main plots at all times. Both stocking treatments achieved a stubble height of 5 to 7 cm within the first 5 d, and this was maintained for the entire period in the continuous stocking treatment.

Plant densities were determined on all subplots by counting live plants contained in six 0.1-m² randomly placed quadrats in April 1997 (initial) and November 1998 (final). Stand survival was then calculated as (final plant counts m⁻²/initial plant counts m⁻²) × 100. For the hay management main-plot treatment only, each subplot was harvested with a flail mower at an early bloom stage (approximately 10% bloom) during the April–November period of both years. This resulted in five harvests per year at Eatonton and six harvests per year at Tifton. At each harvest, subsamples were taken to determine dry matter concentration, and all plot yields were calculated on a dry matter basis. All data were statistically analyzed by PROC ANOVA or PROC GLM, and means were separated via protected ($P \leq 0.05$) LSD (SAS Inst., 1982). Throughout this paper, all mention of significant mean comparisons was made using $P \leq 0.05$.

Table 1. Stand survival over 2 yr (1997–1998) as influenced by different management treatments at Eatonton and Tifton, GA. Data pooled across cultivars.

Management treatments	Survival, %†	
	Eatonton	Tifton
Continuous stocking	38	24
Rotational stocking	53	46
Hay	52	63
LSD ($P \leq 0.05$)	5	7

† (Final plant counts m⁻²/initial plant counts m⁻²) × 100.

RESULTS

Stand survival among the main management treatments showed different trends between the locations (Table 1). At Eatonton, similar survival was recorded for the rotational stocking and hay harvest treatments, with all entries in both of these treatments exhibiting better survival than the same entries in the continuous stocking treatment. At Tifton, there was progressively better stand survival as management changed from continuous stocking to rotational stocking to hay harvest management.

With continuous stocking at both Eatonton and Tifton, Alfagraz showed higher plant densities and survival rates than Apollo but was no different than the grazing selected entries—GA-5432-S2, GA-Apollo-S2, GA-Diamond-S2, and GA-FL77-S2—for these same variables (Tables 2 and 3). At Eatonton, GA-Apollo-S2 and GA-5432-S2 possessed higher plant densities and survival rates than Apollo and their parental populations in the continuous stocking treatment, but no alfalfa entry differences were seen for both the rotational stocking and the hay harvest treatments (Table 2). At Tifton, GA-FL77-S2 and GA-Diamond-S2 demonstrated better stand survival and final plant density in the continuous stocking treatment than their parentals and although they showed better stand survival than Apollo, their final plant density was no different than that of Apollo in the same treatment (Table 3). GA-FL77-S2 and GA-Diamond-S2 also demonstrated better survival than their parentals in the hay treatment while GA-Diamond-S2 gave better survival than Diamond in the rotational stocking treatment at Tifton (Table 3). When averaged across management treatments, each grazing-tolerant population showed a higher survival rate at each test location than the parental population from which it was derived (Tables 2 and 3).

The dry matter yields recorded in the hay manage-

Table 2. Plant density, stand survival, and dry matter yield of different alfalfa cultivars and populations at Eatonton, GA, during 1997–1998) with three management treatments (grazing with continuous stocking, grazing with rotational stocking, and hay management).

Cultivar or population	Plant density†		Management treatment				Hay yield kg ha ⁻¹
	Apr. 1997	Nov. 1998	Continuous	Rotational	Hay	Average	
	plants m ⁻²		Survival, %‡				
Alfagraz	185	80	48	60	53	53	7372
GA-5432-S2	183	81	47	51	59	53	7600
5432	181	37	25	49	52	42	7701
GA-Apollo-S2	172	83	48	58	62	55	7015
Apollo	150	44	31	53	49	44	7460
LSD (<i>P</i> ≤ 0.05)	34	16	13	NS	NS	8	616

† Continuous stocking treatment only.

‡ (Final plant counts m⁻²/initial plant counts m⁻²) × 100.

Table 3. Plant density, stand survival, and dry matter yield of different alfalfa cultivars and populations at Tifton, GA, during 1997–1998 with three management treatments (grazing with continuous stocking, grazing with rotational stocking, and hay management).

Cultivar or population	Plant density†		Management treatment				Hay yield	
	Apr. 1997	Nov. 1998	Continuous	Rotational	Hay	Average	1997	1998
	plants m ⁻²		Survival, %‡				kg ha ⁻¹	
Alfagraze	71	31	41	63	81	61	8377	6987
Apollo	67	11	17	39	48	35	7985	8511
GA-FL77-S2	65	22	33	64	83	60	7779	8998
GA-Diamond-S2	63	20	33	48	63	48	8471	8084
Diamond	55	5	9	19	43	23	7233	6266
Florida 77	47	6	14	45	61	40	7894	6492
LSD ($P \leq 0.05$)	13	11	14	20	19	10	NS	1198

† Continuous stocking treatment only.

‡ (Final plant counts m⁻²/initial plant counts m⁻²) × 100.

ment treatment did not exhibit a year × alfalfa entry interaction at Eatonton (Table 2) but did show a significant year × entry interaction at Tifton (Table 3). At no time at either location, however, was yield of the grazing-tolerant populations inferior to that of its parental population. In fact, at Tifton during 1998, the GA-FL77-S2 and GA-Diamond-S2 populations gave better yield than their parental base cultivars, Florida 77 and Diamond, respectively, probably due to their better stand survival (Table 3).

DISCUSSION

The continuous stocking treatment was actually the NAAIC standard test for grazing tolerance (Bouton and Smith, 1998). The test protocols recommend initial plant densities for all entries of >90 plants m⁻² and final densities for Alfagraze in the range of 40 to 82 plants m⁻² and Apollo in the range of 5 to 38 plants m⁻². Survival is recommended to range 29 to 60% for Alfagraze and 3 to 38% for Apollo. When data from the continuous stocking treatment were analyzed as a standard test (Tables 2 and 3), the grazing-tolerant check, Alfagraze, and the intolerant check, Apollo, separated as expected at Eatonton for final plant numbers and stand survival. GA-5432-S2 and GA-Apollo-S2 could therefore be labeled grazing-tolerant based on the main protocols of the test (e.g., final stand density and percentage survival within the expected ranges for the checks and not significantly different from Alfagraze but significantly better than Apollo). At Tifton, there were lower-than-expected initial stands for all entries and lower-than-expected final stands for the checks (Table 3). The reason for this is unknown but is speculated to be poor soil moisture during the first few weeks after sowing. Even with this initial stand problem, GA-FL77-S2 and GA-Diamond-S2 did show higher survival rates than Apollo although these three entries were not different in plant density. Therefore, GA-FL77-S2 and GA-Diamond-S2 were judged grazing tolerant based only on percentage survival.

The grazing approach used for the NAAIC standard test for grazing tolerance (Bouton and Smith, 1998) as well as the continuous stocking treatment in these current studies are ideal to meet two main criteria of most screening procedures: (i) exposure of all plants to all of the main stresses (in this case, defoliation, trampling,

defecation, etc.) and (ii) uniformity of exposure of each plant to these inherent stresses to prevent *escapes* (Smith et al., 2000). The approach has worked well in identifying grazing survival differences among forage species and cultivars within species (Bouton et al., 1993, 1997b; Brummer and Moore, 2000; Smith and Bouton, 1993). Selection after exposure to intensive, long-term continuous stocking has also resulted in development of grazing-tolerant alfalfa cultivars from an array of genetic backgrounds (Bouton et al., 1991; Bouton et al., 1997a; Moutray, 2000). Because this type of screening and selection is specific for a situation not recommended for alfalfa, then what has been lost by cultivars selected in this manner when used in recommended management systems such as hay making and controlled, rotational grazing? From these current studies, the simple answer appears to be that cultivars selected with continuous stocking perform as well as or better than the best check cultivars in any management situation (Tables 2 and 3).

One possible explanation for the success of the grazing-tolerant alfalfa populations in these current studies is better environmental adaptation (e.g., soils, climate, inherent pests, etc.) than their parental cultivars. Because they were selected in the same geographic area of these current experiments, they may be more adapted to the test environment than the parents. One way of monitoring this effect of adaptation is to examine the performance of the grazing-intolerant checks. Apollo has a 20-yr history of performing well in traditional performance trials at locations in northern Georgia, including Eatonton (Bouton et al., 1982; Smith and Bouton, 1993) and could be considered *adaptive* based on this long-term performance. Florida 77 is definitely adaptive, having been developed for the coastal plain region of southeastern USA (Horner and Ruelke, 1981) and performing well in trials at Tifton, GA (Bouton and Monson, 1985; Bouton et al., 1998). Diamond and 5432 were developed outside the region and, for discussion purposes in this paper, are *nonadaptive*. At Eatonton, there was no advantage for stand survival across management treatments when Apollo (adaptive) was compared with 5432 (nonadaptive) (Table 2). There was a significant advantage for Florida 77 (adaptive) over Diamond (nonadaptive) when averaged across management treatments at Tifton for stand survival (Table 3). Therefore, cultivar adaptation to the soils, climate, and inherent pests may have been important at Tifton. Re-

ardless, there was an improvement in performance (both stand survival and yield) when averaged across management treatments for all grazing-tolerant populations when compared with their parent cultivars at both locations (Tables 2 and 3).

In summary, these studies indicate no loss of performance in any management situation for alfalfa populations selected using procedures employing long-term intensive grazing with continuous stocking. In fact, these grazing-tolerant populations appear to actually have an advantage over good checks, which supports previous reports of a positive commercial value when using grazing-tolerant cultivars in many management situations (Moutray, 2000). It is therefore a good strategy for producers practicing continuous stocking, rotational stocking, and/or hay making to use grazing-tolerant cultivars rather than cultivars not selected for grazing tolerance.

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